DOCUMENT RESUME

ED 457 120 SO 033 021

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TITLE Voices of Women Mathematicians: Understanding Their Success Using a Narrative Approach to Inquiry.
PUB DATE 2001-00-00
NOTE 37p.; Paper presented at the Annual Conference on Interdisciplinary Qualitative Studies (Athens, GA, January 12-14, 2001).
PUB TYPE Reports - Research (143) -- Speeches/Meeting Papers (150)
EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS *Females; *Gender Issues; Graduate Study; Higher Education; Interviews; *Mathematics Teachers; Qualitative Research; *Self Concept
IDENTIFIERS *Mathematics Careers; Mathematics Teacher Beliefs Study; Narrative Inquiry; *Voice (Rhetoric)

ABSTRACT

This study investigated the lives of six women mathematicians to describe the factors and experiences that led each woman to become successful in mathematics. Because "voice" was used as a metaphor in this study, emphasis was placed on listening to and interpreting the participants' voices. The study used narrative inquiry to investigate the women's personal background, self identity, relationships, professional development and career, and the role that gender plays in their lives. Findings suggest that these women were encouraged in mathematics by parents and teachers. Data suggest that the women held strong views of themselves, though there was some evidence that several of the women felt insecure and inadequate. There was evidence that the women's lives were composed of many different components and did not solely revolve around their careers. The women identified reasons for becoming mathematicians, which included their love for mathematics and strong parental and teacher support. The women also perceived gender as playing three different roles in their lives, which were positive, negative, and neutral. They also provided insights into why women are not in mathematics and made recommendations on ways to support girls in mathematics. (Contains 34 references; interview guide is appended.) (Author/BT)

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VOICES OF WOMEN MATHEMATICIANS:

UNDERSTANDING THEIR SUCCESS USING A NARRATIVE APPROACH TO INQUIRY

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ABSTRACT

This article reports a study that investigated the lives of six women mathematicians in order to describe the factors and experiences that led each woman to become successful in mathematics. Because *voice* was used as a metaphor in this study, emphasis was placed on listening to and interpreting the participants' voices. The study used narrative inquiry to investigate the women's personal background, self-identity, relationships, professional development and career, and the role that gender plays in their lives. Findings suggest that these women were encouraged in mathematics by parents and teachers. Data also suggest that the women held strong views of themselves, though there was some evidence that several of the women felt insecure and inadequate. There was evidence that the women's lives were composed of many different components and did not solely revolve around their careers. The women identified reasons for becoming mathematicians, which included their love for mathematics and strong parental and teacher support. The women also perceived gender as playing three different roles in their lives, which were positive, negative, and neutral. They also provided insights into why more women are not in mathematics and made recommendations on ways to support girls in mathematics.

VOICES OF WOMEN MATHEMATICIANS:

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> *Teresa*: The main point I want to get across is that being a woman in mathematics, means to me, not being a women in mathematics, you know what I mean, sort of being like everybody else and realizing that everyone is a person first and that's the only way I can survive.

INTRODUCTION

This exploratory study is an investigation into the lives of six women mathematicians from various backgrounds and educational environments. This research evolved as an outgrowth of my interests in mathematics, mathematics education, feminist theory, and gender issues. In an effort to connect these four domains, I chose to investigate women mathematicians. As a feminist researcher in mathematics education, I was interested in exploring the issues facing women as mathematicians, particularly how they perceived themselves in what is generally seen as a male-dominated field. Issues surrounding their place and voice in the discipline were also examined. The study revolved around answering the following questions: What are the consistent themes in the life stories of women mathematicians? What are the factors and experiences that led each woman to become successful in mathematics?

Theoretical Perspective

Fennema and Hart (1994) challenged the scholarly community to consider research in mathematics education that employs a feminist perspective. Heeding their appeal, my work is situated in and informed by feminist standpoint theory (c.f., Hartsock, 1983; Tanesini, 1999). A major principle of feminist standpoint epistemology is its reliance on knowledge that is created by and situated within the viewpoint of women. Women construct their own knowledge and do so

differently than men (Tanesini, 1999). This standpoint hinges on the lives, knowledge, experiences, and voices of women. Hartsock (1998) noted that:

> A standpoint is not generated unproblematically by simple existence in a particular social location. It is a product of systematic theoretical and practical work, and its achievement can never be predicted with any certainty. The adoption of a standpoint may require a theoretical migration. (p. 237)

In other words, one does not merely fall into a standpoint because of her allegiance with a particular group but must actively work to achieve a feminist standpoint.

Furthermore, this epistemology assumes women perceive their worlds from a subjugated position that arises from the patriarchal world in which we live. As a result of living in a male-dominated world, women are in a better place to examine the inequities of their position and evaluate those occupying the positions of power and dominance. Tanesini (1999) referred to this position as a privileged epistemic viewpoint (p. 142). Women hold dual social positions that are antithetical in nature. Women play a central role in sustaining the current system but maintain a marginal position in terms of power within the system. Because women are in a less advantageous position, they gain a perspective that is unseen by the dominant male culture. Thus, they are in a preferred position that allows them to view the world with a more finely focused lens, a lens that is clouded for those that hold positions of power. This distinct lens allows women, by virtue of their less powerful position

> to perceive a rupture between what the world is like for them and what dominant views say about it. It is this 'line of fault' which alerts women that something is amiss. Starting from their experiences it is possible for them to expose those aspects of social reality that are

invisible from other positions. (Tanesini, 1999, p. 142)

Herein lies the privilege that women possess. Maintaining allegiance with Harding (1991), Damarin (1995) argues that "women can know the world in valid ways that are not available to their oppressors; because they have less to lose in changing their status quo, they are less bound to it and better able to examine it" (p. 247).

Implicit in this feminist theory is the concept of multiplicity (Damarin, 1995). Multiple feminist standpoints exist; there is no single feminist standpoint. For example, women from diverse ethnic backgrounds, such as African American (e.g., Collins, 1990), Latina, and Third World women maintain different standpoints. Proponents of this ideology believe a feminist standpoint must be actively pursued and constructed as a way of knowing that hinges on the lives and experiences of particular women (Damarin, 1995). Harding (1991) declared that "we must insist on an objective location—women's lives—as the place from which feminist research should begin" (p. 123).

To fully engage in the lives of particular women, women's voices are paramount, not only in understanding their experiences, but also in achieving a feminist perspective. "Voice refers to the discourse that is created when people [women] define their own issues in their own ways, from their own perspectives, using their own terms--in a word they speak for themselves" (Secada, 1995, p. 156). Women's voices shed light on their perspectives as seen through their lenses. By listening to their voices, we have an opportunity to glean insight into their worlds and to provide a forum for women to voice their thoughts.

My research, guided by a feminist-standpoint epistemology, allows educators to listen to the voices of women mathematicians that have progressed through various educational systems to achieve success. Their narratives are tools for understanding their success and for providing a forum

to critically examine how these women became successful in mathematics. These six narratives provide models that may help those who teach girls from diverse environments discover ways to be successful in mathematics. This study provides insight into understanding the experiences, both mathematical and non-mathematical, of women mathematicians. It aspires to draw attention to these women's narratives and magnify their perspectives so that we may more clearly envision and understand their worlds.

Related Literature

The few feminist scholars who are investigating women's experiences in mathematics, and incorporating women's voices in the research follow in the footsteps of Buerk (1982; 1985; 1990; 1996). Her research primarily focuses on listening to women's voices who tend to be math avoidant. By listening to women's voices relay the ways in which they create meaning in mathematics and reasons why they avoid mathematics, Buerk has developed strategies for educators to use in helping all students who tend to avoid mathematics have a positive mathematical experience (Buerk, 1985). Allowing the voices of the women to be heard through their writing is also a central focus of her studies.

Other scholars adding to this area of inquiry are Erchick (1996), Koch (1996), McSheffrey (1992), Moody (1997), Maple (1994), Stage and Maple (1996), and Zeldin and Pajares (2000). Erchick's (1996) research revolved around exploring women's experiences in mathematics as they relate to work by Belenky, Clinchy, Goldberger, and Tarule (1986). Her work employs feminist life history methodologies in an attempt "to find, describe, and at the very least begin to understand women's epistemological positionings as they develop relationships with mathematics" (Erchick, 1998, p. 2).

In an effort to establish the existence of stages of mathematical development framed within *Women's Ways of Knowing* perspectives, Koch (1996) listened to the voices of two female minority students who were enrolled in a developmental mathematics course. By listening to these women's voices, Koch was able to discern what stage of mathematical development each were in at the time. Koch argues that " the results . . . suggest the possibility of stages of mathematical development which can be discerned through mathematical voice" (1996, p. 174).

McSheffrey (1992) attempted to understand why girls and women avoid mathematics based on narrative accounts of their mathematical experiences. Through letters, stories, and personal interviews, participants conveyed the important role that teachers and parents play in regards to their mathematical experiences. Participants fondly recalled teachers who made them feel "special, cared for, honoured and liked" (p. 61) as well as teachers who connected the mathematics with their lives. The girls and women also expressed support or lack of support by their parents. McSheffrey argued that having students share their students be an integral part of the classroom. He "encourages mathematics teachers to tell their stories and to ask their students to share their stories as well" (p. 64).

Using voice as a metaphor for her study, Moody (1997) related the stories of two African American female college students who were successful in school mathematics. She allowed them to speak for themselves about their schooling and mathematical experiences and how they became successful in mathematics. Using a phenomenological approach to data collection and analysis, Moody sought to explain, describe, and interpret the women's voices as they spoke about success in their schooling and mathematical experiences. The study was situated within a critical theory perspective and positioned the students' experiences in a broader social context. Moody was

interested in understanding "the mathematical experiences of African American students who have been successful in school mathematics given the existing social structure" (1997, p. 36). The voices of these African American females students highlight the inequities that existed in their schooling experiences, particularly tracking. The research conducted by Moody served as a backdrop for my study in that my work used voice as a metaphor to relay the experiences of women mathematicians who have been successful in mathematics. My study differed from Moody's work because I used a feminist framework instead of a critical theory perspective. I also focused on gender as an important factor in understanding the participants' success in mathematics while Moody focused on race.

Using a feminist perspective on science and a qualitative approach to data collection and analysis, Maple (1994) explored the background, educational experiences, and career expectations of female doctoral students in mathematics and science. Maple found that support from parents and school officials was significant to her participants in helping them to pursue a degree in mathematics and science. The participants also expressed a sensitivity to an encouraging graduate school environment and mentioned that as they flowed through the mathematics and science pipeline from undergraduate to graduate study, the school environment seemed to be lacking in a support system. Maple noted that the way women perceive cultural definitions of commitment and dedication in mathematics and science may be incompatible with the nature of the way they view themselves and their life roles. My study is partly an extension of Maple's study. Using a feminist standpoint perspective, I explored the lives of six women mathematicians to identify the factors and experiences that led each woman to become successful in obtaining her doctorate in mathematics.

Building on Maple's (1994) doctoral dissertation, Stage and Maple (1996) conducted a study that is similar to my research. Using the narratives of seven women that had obtained a bachelor's

degree in mathematics, the researchers identified reasons why these women left the mathematics pipeline to become a research mathematician in order to pursue a doctorate in education. Three themes emerged from their analysis of the women's narratives: their participation in the mathematics/science pipeline; their relationships to the subject of mathematics; and their awareness of the differences between how they perceived themselves and the culture of mathematics, in particular, mathematics as a career.

In their recommendations, Stage and Maple (1996) argued that "more detailed information, including narratives of people who are successful in their pursuit of hard science doctorates and research faculty positions, might be useful" (p. 41). Stage and Maple illuminated another issue that guided my research. They argued that "for women who remain in the pipeline, perhaps they too are able to cope better with the culture and the pressures of graduate mathematics study" (1996, p. 37). I investigated their assumption by studying four women who have successfully navigated their way through the mathematics pipeline. Two of the participants were doctoral students at the time of the study, so they provided perspectives from women who were still in the pipeline. Stage and Maple "hope that through their study educators will learn of ways to encourage more students, both male and female, to remain in the mathematics pipeline" (1996, p. 37). Similarly, by listening to the voices of successful women mathematicians, I hope to encourage educators to use these women's life experiences as models in order to encourage more girls to excel in mathematics.

METHOD

Participants

I chose six women mathematicians to participate in the study using a criterion-based selection approach (LeCompte & Preissle, 1993). The criteria for selection were females who had

obtained a doctorate in mathematics or were enrolled in a program leading to a Ph.D. in mathematics. The participants' status and backgrounds are summarized in Table 1.

Table 1
Status and Background of Participants

	Status	Age	Birthplace	Race	SES (childhood)	Occupation of mother	Occupation of father
Emmie	professor*	40	Connecticut	Caucasian	Upper Middle	violinist	economics professor
Faith	professor**	28	South Carolina	Caucasian	Middle	homemaker, elementary teacher	professional
Iona	professor*	33	Iran	Caucasian	Middle	teacher	military
Teresa	doctoral student*	28	South Florida	Hispanic-American	Middle	writer, English professor	retail management, high school teacher
Marisa	professor*	late 30's	Croatia	Caucasian	Middle	elementary teacher	high school teacher
Sonia	doctoral student*	41	Kentucky	Caucasian	Middle	waitress, bartender	custom painter, locksmith, bartender

*indicates position at a large state research university
**indicates position at a small private liberal arts university (primarily teaching institution)

Data Collection

Atweh and Cooper (1995) call for diverse qualitative research methodologies such as life histories that "take into account the experiences of girls who were successful in school mathematics" (p. 307). In alignment with this call for future research, my study used a narrative inquiry approach for data collection and analysis. I was intent on giving voice to women thereby enabling them to share their stories. "As a research technique, the study of experience is through stories. Emphasis is on the stories people [women] tell and how these stories are communicated—on the language used to tell the stories" (Merriam, 1992, p. 157). Data included one semi-structured interview that was

audio-taped interview. During one-month in the fall of 1998, I conducted the seven interviews using an interview guide (see Appendix). I created the interview guide based on literature in the field related to gender and mathematics education, feminist theory, and from an interview protocol used by Belenky, Clinchy, Goldberger, and Tarule (1986). The women were asked to share their thoughts and feelings about issues involving their personal background, self-identity, career, and gender, particularly the role it plays in the workplace. The interview took on a relatively flexible form of questioning based on a semistructured approach to the interviewing process (Merriam, 1998). I interviewed each woman in her campus office expecting this would make her more comfortable and allow a glimpse into their professional world. Each interview ranged from 45 minutes to two hours. After I collected the data and transcribed the interviews, I checked each transcript against the tapes two times to make sure that the transcripts were an accurate representation of what was said by each participant. To ensure confidentiality, the participants each agreed to the use of pseudonyms. I used member checks (Lincoln & Guba, 1985) in order to maintain credibility and trustworthiness of the data. After I analyzed the data, I gave each participant a copy of my initial findings and asked her to review for corrections or modifications in the interpretation of the data.

Data Analysis

Narrative analysis revolves around the stories that people tell to give meaning to their lived experiences. Reissman (1993), a scholar in the field of narrative inquiry, notes that the purpose of narrative analysis is "to see how respondents in interviews impose order on the flow of experience to make sense of events and actions in their lives" (p. 2). Narrative analysis is on understanding how people interpret their world via stories that they tell and retell. The story is the unit of analysis. What the narrator says is just as important as *how* the narrator speaks about her or his experiences.

Reissman (1993) urges those conducting narrative analysis to focus on answering the question, "Why was the story told *that* way?" (p. 2). What becomes important is the how the narrative is organized, how the narrative begins and ends, and what is revealed and hidden in the narrative and why.

It would be fruitless to name all of the scholars who have contributed to the field of narrative inquiry. Prominent scholars working in this area of narrative inquiry are Jerome Bruner, D. Jean Clandinin, F. Michael Connelly, M. Cortazzi, W. Labov, Elliot Mishler, Donald E. Polkinghorne, and Catherine Kohler Riessman, to name a few. However, there are many others working across disciplines. Narratives are not only limited to stories. What counts as narrative is open to debate. Personal narratives come in many forms. Narratives are evidenced in poetry, painting, dance, film, fiction and non-fiction writing, African-American women's quilts, and an endless array of art forms. In an attempt to discuss one particular form of narrative, I will use Reissman's (1993) definition of narrative, which is "talk organized around consequential events. A teller in a conversation takes a listener into a past time or 'world' and recapitulates what happened then to make a point, often a moral one" (p. 3).

Narratives can be analyzed using various approaches, which range from formal approaches to less systematic approaches. If one were to approach narrative analysis using a formal approach, there would be an emphasis on the structure and identifiable properties of narratives. Labov identifies six properties of a "fully formed" narrative, which include abstract (summary of the substance of the narrative), orientation (time, place, situation, participants), complication (sequence of events), evaluation (significance and meaning of the action, attitude of the narrator), resolution (what finally happened), and coda (returns the perspective to the present) (Reissman, 1993, p. 18). Several scholars such as Cortazzi and Reissman have adapted and modified Labov's model to create their

own model for analyzing the structure of a narrative.

The analysis of narratives can also take a less formal approach. There exists in the literature a wide range of narratives that are analyzed for their function rather than their structure. For example, Coffey and Atkinson (1996) note that narratives can also be analyzed in terms of content and function. Narrative analysis from this perspective emphasizes the socio-cultural historical context that the narrative is situated. Coffey and Atkinson (1996) provide two examples that illustrate the functional properties of narrative, which include narrative as a way to convey success stories and moral tales and narrative as a way to describe the life experiences of an individual over time and place (narrative as chronicle). Reissman (1993) also provides a variety of approaches to narrative analysis.

Advice from Coffey and Atkinson (1996) guided my data analysis. Coffey and Atkinson advised that:

> There are no formulae or recipes for the "best" way to analyze the stories we elicit and collect. Indeed, one of the strengths of thinking about our data as narrative is that this opens up the possibilities for a variety of analytic strategies. (p. 80)

Rallying around this idea, I used an informal approach to analyze each of the women's narratives. In particular, I used a paradigmatic approach described by Polkinghorne (1995) called an *analysis of narrative*. This approach begins with participants' narratives and progresses to common themes shared across the narratives. To illustrate Polkinghorne's method, I began my data analysis by reading the transcribed interviews making notes in the margin and searching for emerging themes in each narrative. I read each narrative separately to identify themes that emerged that were particular to each narrative. After I identified the initial set of themes particular to each narrative, I reread each

narrative several more times to be clear that I had captured all of the significant themes that were embedded in the data. Once I identified the themes particular to each narrative, I searched across the six narratives to determine if there were any themes that were common. When I identified the final group of shared themes, I reread the transcripts to search for confirming and disconfirming evidence. The shared themes that emerged from the data were women's early experiences and family expectations; perceptions of identity; social relationships and commitments; issues revolving professional development and career, in particular, reasons for becoming a mathematician and concerns surrounding being a woman in a field dominated by men; reasons for why there are not more women in the field of mathematics; and ways to increase the number of women in mathematics. In the next section, I illustrate the shared themes using the women's narratives. This section attempts to show that "the analysis of narratives can provide a critical way of examining not only key actors and events but also cultural conventions and social norms" (Coffey & Atkinson, 1996, p. 80).

Data Presentation

Early Experiences and Family Expectations

Each woman spoke about supportive parents who offered varying degrees of encouragement. For the most part, the women referred to parents as encouraging their daughters to "be happy" and to pick a career that interested them, and most parents were open to the career choices their daughters made. Iona's parents held high aspirations for her, expecting her to become a doctor due to the high prestige that the profession maintained in her homeland. Iona, in her teens, however, set her sights on becoming a university professor:

I really liked school. So I thought, what I want to do is just keep learning for the rest of my

> life, and the thing that comes closest to that is being a university professor. I guess that's when I sort of decided I was going to be a university professor.

In the end, her parents supported her decision.

Teresa perceived her parents as reassuring. "My parents were very open minded and liberal. They thought that I could pretty much do anything I wanted, and so, whenever they saw me getting discouraged in science and math they encouraged me to continue to persist." As a young child, Teresa continuously heard mixed messages about the roles that women should play:

> I was getting a lot of signals that women shouldn't be in mathematics, and it's okay to make a D or a F on those math tests because women aren't supposed to be in mathematics and are not supposed to be very good at it. You are supposed to be a writer, do something like history or social sciences. I guess my parents refused to let that happen.

Teresa shared a poignant story that illustrated the support that she received from her parents, in particular, her father:

> My dad likes to tell the story that I came home from third grade one time and I was trying to do my homework and I said, "I just can't do it, I can't do it. My teachers say it's okay because I am a girl." He just got furious. He made me sit down with him for several nights and just work problems. He even told me, "Don't think like that," that I can do anything that I wanted to do. I think that was a real turning point. I think because I listened to my parents I ended up in the field.

Teresa's parental support system helped encourage her to study mathematics. Similarly, in her research with female doctoral students in mathematics and science, Maple (1994) found that supportive parents were positively related to women's interest and participation in mathematics and

science. Zeldin and Pajares (2000) also reported similar findings.

Perceptions of Self Identity

Not surprisingly, the women expressed strong views of themselves. Throughout their stories, the voices of the women sounded resolute, convincing, and powerful; one could even say they sounded Herculean. Overarching Emmie's narrative was a powerful sense of self:

> I have a strong sense of doing things the way I want to do them. I kind of see that as maybe one of my main characteristics. I try to make things my own and do things, whatever, I am doing, in my own way, whatever that is, whether that is similar to what other people are doing, or not similar to what other people are doing . . . . nobody is going to tell me what I can't do.

The self-descriptions of each woman resonated with themes of independence, mottoes of persistence, and patterns of driven behavior. Iona described herself by stating, "I don't give up easily on anything, whether it's mathematics, whether it's life." The women perceived themselves as being stubborn, ambitious, hard working, accomplished, determined, outspoken, dedicated, tough, and smart. Iona shared two perceptions of herself that lengthen the list of descriptors expressed by each woman. She communicated that "I learn very fast" and "I like to be challenged. If something is too easy, I don't like it."

The women also perceived themselves as caring deeply about their work and people, and deriving pleasure from teaching. Sonia expressed this sentiment in the following way:

> I taught high school math, between my senior year and going to college. I taught high school level Trig and Pre-Calculus and Algebra during that summer. I loved it when students who hated math or just said, "I can't do it, I can't do it," and all of a sudden I found some way to

> teach several, not all of them, but several of them that they actually could do it, and that it actually could be interesting and fun and they could think of it as a puzzle. I saw young, bright minds actually open to a subject that they hadn't been open to before. To me that is one of the most exciting experiences to watch somebody sort of blossom and flower.

Iona conveyed a similar perspective based on her experience of teaching Calculus. "I have fun teaching it. It's because of the students. So, it's not the scientific part of it that's interesting, it's the human part of it, the human interaction part of it."

Not in any particular order, the women identified multiple roles that they fulfilled such as mathematician, mathematics professor, mother, wife, daughter, and sister. Emmie established the importance of her roles when she firmly asserted "mother, wife, math professor, in that order."

Iona discussed one aspect of her character that reflected her willingness to look inward and be truthful about herself. "I try at least to be honest with myself. I try to always face myself to see what I am and accept what I am." Similarly, Faith struggled with the same ideal when she stated, "I sometimes tend to feel like I have to prove myself. One thing I have been working on recently is accepting that I am an okay person even if I don't do all work perfectly." Teresa shed light on the way she defined herself, in terms of her relationships with others, and in particular, her relationship with herself:

> I define myself through my relationships now, but only partially. I mean, I don't define myself as a girlfriend, as a friend. I think that all comes into play, it all goes into the pot. But I also have a relationship with myself that goes into that. I was an only child, and my mother is a very private person. So I tend to be pretty private, and I need some *me* time. I spend a lot of time thinking about what kind of a person I would like to be. Am I fitting into my idea of

who I am? Are my actions echoing what I feel about myself? I spend a lot of time doing that when I am alone. So I guess that all goes into the pot. I have my relationships with my friends, parents, ex-husband, and boyfriend. I define myself through my relationships, but the biggest relationship would be the one with myself.

Contrary to the strong identities that the women held, several of the women expressed feelings of insecurity and a lack of self-confidence. Sonia mentioned the source of her feelings of inadequacy:

> I have less self-confidence socially than I used to, but I think a lot of that is because I am around so many really self-confident people here [at the university] that after awhile the lack of self-confidence becomes engraved in everything that I do.

Faith revealed similar feelings:

> I guess I always heard growing up, you are so smart, you are so smart, you are so smart; but I was interested in math at an early age. But I always wanted them [boys] to say, I wished they would say I was beautiful. I wished he would say I was charming, or I wished he would say I was adorable or something that has feminine overtones. For some reason, intelligence to me, it wasn't that it didn't have feminine overtones, but it was always there for me. I wanted something else. I guess we are all that way socially, when we have one thing we want something else. Right? Part of the accepting, part of it has been accepting the fact that I am better at math than a lot of women, most men, and most people. And part of it is because I worked hard at it. At some point it's like, oh! I have worked hard at it. I can be proud of the fact that I have worked hard at it and so that's something that I don't know that that's particularly a gender thing.

Faith's personal commentary reflects the dichotomous messages that many young girls and women receive as they grow and mature in our "girl poisoned culture" (Pipher, 1994). Young girls and women are informed at an early age that intelligence and beauty are two separate entities, each attribute gendered in nature. In American culture, beauty secures a feminine overtone whereas intelligence is relegated to a masculine domain. This cultural notion is often reflected in the areas of mathematics, science, and technology which are highly regarded fields that attract bright and rational people. In these fields, men still outnumber women (National Center for Education Statistics, 1997).

Faith's comment that she wanted something else implied that her intelligence was insufficient in defining herself as a valuable woman. To be seen as having more worth as a woman, it was necessary to be thought of as beautiful, pretty, cute, or adorable. Faith's remark suggests that our culture continues to perpetuate the myth that women are deemed valuable and worthwhile based on their outer appearance. This view, elevated in the media and advocated in the socialization of young girls, should be reconstructed so that women are valued for their abilities rather than appearance.

It was evident from listening to these women communicate their thoughts about their self-identity that they perceived themselves as multi-faceted due to the many roles they performed throughout their lives. They also possessed a strong sense of independence that was apparent in their life choices.

Social Relationships and Commitments

The lives of these women did not revolve solely around their careers. Each woman noted the importance of building relationships outside of her mathematics community and professional life. Strong bonds with family and friends were vital in the maintenance of their worlds. Upon entering Emmie's office, I noticed the elements usually associated with being a mathematics professor: books

about advanced mathematics stacked on shelves, student papers anxiously waiting to be graded, and a computer waving the message "You have new mail." Off in the corner, I caught a glimpse of children's toys lying haphazardly on the window sill. Instantaneously, I discerned from that miniature stage the importance of her children and the precedence they held in her life. Emmie's decision to work part-time and devote more time to her family is representative of many women's efforts to live lives that honor multiplicity rather than singularity. Bateson (1989), a scholar who studied successful women, argued "Perhaps we can discern in women honoring multiple commitments a new level of productivity and new possibilities of learning" (p. 166).

Recently, Teresa underwent a major life transition that altered her perspective of her identity and shifted the importance that the role of mathematician played in her life. Teresa described these changes:

> I used to define myself through my work . . . I have gone through a lot of changes that have put a lot of things in perspective for me. But I think being a mathematician is very important but is now secondary to being a person. I am learning that work is not as important as my personal life and my personal relationships, and mathematics can give me a certain amount of happiness, but it can't give me everything. It can't be my sole means of support, emotional support.

Teresa elaborated further on the significance of human relationships as a source of passion in her life when she expressed:

> What is more important to me I think are the times when we are not doing mathematics, when we are being people together, people who share similar experiences, who are under the same pressures, and we help each other out . . . . I think my passions are people now instead

of work not that work is not a passion. I think it's secondary to people.

Outside of building solid human relationships, the women displayed their multidimensionality in their sundry hobbies ranging from music, art, and film to exercising, cross-stitching, and reading. The women also unearthed pleasure by being involved in their church and religious communities and participating in volunteer organizations. Bateson (1989) captured my thoughts about these women when she wrote, "Their purity lies in their embrace of multiplicity" (p. 233).

Professional Development and Career

Reasons for becoming a mathematician.

The women reported that they were drawn to the field of mathematics by their love for mathematics and science. Faith proclaimed that "math is the only thing I have ever wanted to do . . . . There has just never been any question in my mind." Sonia described the intensity with which mathematics enveloped her life. "I knew that my passion for mathematics had driven me to the point of lack of comfort in my life and it was okay. I have to do this. I have to find out if I can do this." Emmie's love of mathematics originated in its beauty. She viewed mathematics as "neat, beautiful, and interesting." As a result of doing well in mathematics early on in their lives, the women evidenced a natural progression towards mathematics and sciences. Iona voiced her thoughts on this topic:

> It [mathematics] had this kind of clout for me as I was growing up, and the other thing was that it was sort of the thing I was best at in school. I was good in everything, but math was still the thing where I really felt that I was really on top of it. I didn't feel any weakness in there [mathematics] at all. So that's another reason. You want to do the thing you feel you

are best at too.

Other reasons for venturing into the field of mathematics were that their families and teachers encouraged the women. Sonia asserted the importance that a woman teacher had in influencing her career choice:

> In her class I loved it. I got excited because I was allowed to like math and sciences in the open . . . just for that one hour every day. But I was allowed to actually enjoy myself and enjoy the math and sciences in the open other than being embarrassed about the fact that I enjoyed it.

Sonia's comment is alarming because it provides additional evidence of the misconstrued societal expectations for women in mathematics. Fortunately, Sonia's mathematics teacher helped counteract the societal messages that Sonia was receiving by allowing and encouraging her to enjoy and excel in mathematics.

At the age of 31, Sonia decided to go back to school because of her "natural interest" in school. What Sonia discovered by returning to school and taking a mathematics course was a sense of home:

> When I sat down and did the mathematics I had a sense of home, even in a place where I didn't feel like I was home. I had a sense of self, that I was doing something that was right for me and belonged to me and it was so exciting, and so wonderful to have this incredible feeling of, "This is it, this is me." This is part of me, and I couldn't stop.

Faith also expressed the satisfaction she found in being a mathematician and mathematics professor when she remarked, "If my life were to end tomorrow, am I doing what I want to be doing and the answer was yes."

Gender issues in a field dominated by men.

The women perceived gender as playing different roles, which I have organized into *positive* (helpful), *neutral* (irrelevant), or *negative* (hindrance) roles. The women's perceptions of gender did not remain fixed; gender was perceived differently depending on the context or situation. Several women recalled instances where gender played a positive role, meaning gender facilitated their lives as mathematicians. Emmie, Teresa, and Sonia thought that being a woman in the field of mathematics had actually helped them. Teresa and Sonia perceived the benefit in terms of affirmative action policies and opportunities for funding that were available to them as women for their advancement in mathematics. Emmie provided the following example:

> To a certain extent I think it [being a woman] might have helped me because I think if I were in a department which was predominantly women, and if I asked to take a lot of time off to be with my kids, and to work part-time, I think there would be less receptivity towards that.

For Emmie, being in a department with few women allowed her to teach and also be with her children. This is an interesting contrast to Stage and Maple's (1996) finding that several of their respondents left mathematics because of conflicting notions between their personal goals and the profession.

For Faith, Marisa, and Emmie, gender was perceived as a neutral influence, meaning gender held little, if any, precedence in their professional worlds. Faith perceived herself "as a mathematician that happens to be female" and viewed mathematics as "a gender blind subject." Marisa remarked, "I think it [being a woman] has become quite irrelevant to most people in the field." In her role as a mathematician, Emmie noted, "I'm another person in math, I just happen to be a woman . . . . I'm not really super conscious of the gender issue." Emmie saw her gender as having a

different impact on different aspects of her life as a mathematician. Gender had a positive impact on her ability to balance her chosen career and family obligations, but gender had a neutral effect on her work as a mathematician.

Similarly, Sonia saw both positive and negative effects of gender in her work. She perceived gender as a hindrance or a road block in her work as a mathematician:

> But the whole department seems to not want to recognize gender at all. They don't want to talk about women's issues because they are afraid that they have to recognize that there is gender . . . . They are very careful not to over advise their female students, be over supportive of the female students. They are afraid that would look like they are being sort of gender centric. What ends up happening is that the department seems to leave you out in the cold.

Sonia's statement documents the lack of support that Stage and Maple (1996) identified as cause for some women to leave mathematics. Iona also perceived gender as exhibiting a negative influence in her career as a mathematician:

> I just get this feeling often that, just emotionally, it's harder because most of the things you do, there are so few women doing it . . . . People are less used to that so they don't make it easy for you, so it's like you have to make more of a push.

Iona's statement supports Stage and Maple's (1996) observation that several of their participants left the pipeline due to negative experiences that they endured in their graduate programs.

Apparent in the women's voices were descriptions of *adjustments* that *they made* in order to "fit in" a male-dominated field. Sonia offered the following view. "I . . . never really thought about gender, or never really felt female until I got here [doctoral program] and then I felt like it was in my face all the time." When I asked if the situation had lessened in intensity, Sonia responded "I am not

sure that it is any different now but that I have adjusted to it." Marisa noticed that when she attended mathematics conferences, "there is very little women around." She commented that "I am so used to it that I probably would feel very strange if there were a room full of women." Marisa seems to have accepted the fact that there are fewer women in mathematics. Teresa's comment, "I think my voice [as a woman in mathematics] is that I don't try to be different," conveys her strategy for "survival" in the field. Teresa's statement provides insight into Stage and Maple's (1996) conjecture that women who remain in the pipeline are able to cope with the culture and the pressures of graduate mathematics study. Perhaps Teresa, Marisa, and Sonia have been able to persevere in a patriarchal playing field because they conformed to the existing social situation. Future research might seek to document the extent to which these adjustments have required women to compromise their goals, values, beliefs, or gender to fit in or survive.

Broadening the Horizons for Women's Participation in the Field of Mathematics

The women provided keen insights regarding why more women are not in the field of mathematics and made recommendations on ways to help girls achieve success in mathematics.

Why Aren't There More Women in the Field of Mathematics?

The women identified the manner in which girls are socialized and the low value that is attached to mathematics in American culture as explanations for the low ratio of women to men in mathematics. Teresa remembered in her childhood receiving clear "signals that women shouldn't be in mathematics" and that it was "okay to make a D or an F on those math tests because women aren't supposed to be in mathematics" or do well in mathematics. Similarly, Iona expressed that "it's because people think women aren't as good at math and that sort of brainwashes you." Sonia reflected on her childhood learning experiences and recalled being taught at a young age that "this is

a guy's world" and that boys will not be interested in you if "you are too good in the math and sciences."

Iona agreed that mathematics is not held in high esteem in the American culture. Iona grew up in two cultures—European (Parisian) and Middle Eastern (Iranian)—where mathematics was perceived as having "this kind of clout." She asserted that "one thing that's in common between those two cultures is that mathematics is regarded very highly, which is not the case in this country." This common perception is reflected in the willingness of American people to rationalize their deficiencies in the subject. For example, phrases similar to "Math is my worst course" and "I'm not good in math" and the "My parents were bad in math, therefore I take after them" syndrome are all too common in our math-phobic culture. Women and girls, in particular, are prone to believing messages that relay that mathematics is a difficult subject and that each person inherited a mathematics gene at birth. For decades, cultural scripts have dictated that boys are inherently better in mathematics and science than girls. Fortunately, early studies (e.g., Fennema & Sherman, 1977; 1978) indicated that few sex-related cognitive differences exist in mathematics achievement, suggesting that women are equally capable of achieving in mathematics as compared to men. Fennema and Sherman (1977) found that "the pattern of differences in mathematics achievement . . . strongly suggests the influence of sociocultural factors" (p. 69). Based on these findings, we must find ways to dispel the myth that mathematics is a gendered subject favoring boys.

Sonia believed that she was not encouraged to pursue mathematics because of her family's educational background. She surmised that "my high school never geared me towards academics or going to college because my parents weren't academic, and my parents didn't go to college. So they don't gear you towards your potential. They gear you towards your history." The last portion of her

comment is indicative of the tracking system that is prevalent in American education. Once a student is identified as having low socioeconomic status, being part of a minority group, or doing poorly on an achievement test, and placed in a low achieving track, she or he is rarely extended opportunities to switch routes to a higher achieving path. Sonia's story is cause for investigating alternatives to the current tracking system in mathematics education.

Emmie and Marisa offered two alternative explanations for the scarcity of women in mathematics. Emmie commented that "at the research level, you have to be kind of a real risk taker. . . . you have to be really comfortable with being in a very unstable, unknown situation." Emmie proposed that "it's not true for every individual, but I would say as a group, the women are much happier with a predictable stable situation" as compared to being placed "in a risky, unknown situation." Marisa speculated that "maybe one reason there are not more women in mathematics is that math [research] is such a solitary thing." Marisa's conjecture may stem from the fact that girls are indoctrinated at a young age to be social beings versus independent thinkers and learners and to engage in careers that are related to caretaking. Typically, the culture of mathematics is biased toward men and consequently, tends to have features that are traditionally ascribed to males--competition, isolation, independence, aggressiveness, hierarchy, and long hours that exclude family (Henrion, 1997). Henrion (1997) dispelled the myth held by the public and mathematicians that "mathematics is a solitary thing" where mathematicians do their research in isolation. Research in mathematics is a collaborative effort that involves mathematicians working cooperatively to share and discuss ideas. In fact, from 1940-1998, the MathSciNet database (http://www.ams.org/mathscinet) reported that out of 1,529,104 authored papers, 500,695 (32.7%) papers had two or more authors. This statistic conveys the message that almost one-third of

mathematicians, a significant number, are working collaboratively and suggests that not all mathematicians are working in complete isolation.

What Measures Can Be Taken To Promote Females to Succeed in Mathematics?

The mathematicians offered practical and informative suggestions for increasing girls' participation in mathematics. Most surmised that role models were crucial to involving more girls in the field. Girls must be able to see women doing mathematics from mathematics teachers and professors to people in a wide range of jobs that employ mathematics. Marisa recalled that women teachers were plentiful in her education. Sonia articulated her belief in the need for women role models in mathematics:

> I think women need more encouragement than men do in math and science because most of the time when you were much younger, people told you that women didn't do math and science . . . . You don't believe people when they tell you that, but when you look to see if it is true, well you don't see many women in the math and sciences. So you start believing that it's true and easily discourage yourself from becoming a mathematician. I think maybe mentoring programs and just having more women out there helps . . . . For me it was the one [woman] mathematician in seventh grade who said, "Look, girls can do this too, and this is fun."

It was apparent in most of the women's narratives that they were encouraged in mathematics and science by someone significant such as a parent or teacher that fostered a positive view of the field. Marisa asserted that "I just never was discouraged." She also noted the significant role that her parents played in guiding her into the field. "I know personally that if I had listened to my teachers and the people around me instead of my parents, then I might not have ended up in mathematics."

Maple (1994) and Zeldin and Pajares (2000) found that support by teachers and parents may be a significant factor in women's choice of non-traditional majors, particularly in mathematics and science. Stage and Maple (1996) also identified similar findings in the narratives of their participants that left the pipeline. From early ages, girls should be encouraged and supported in mathematics.

Iona contended that American culture must alter its devalued perception of mathematics and place mathematics on a much higher pedestal. Teresa alleged that change "starts in the home and it starts with the parents. We are going to have to change the society, to teach our children differently, and I think that is going to happen. I have to hope that it is going to happen."

CONCLUSION

I was inspired by listening to the women share their life stories. I admired the open manner in which each woman portrayed herself. Their stories reflected a sense of purpose and identity. It is my hope that by reading these women's stories, other educators and females may take note of their endeavors, successes, and accomplishments and have cause to follow in their footsteps. Teresa affirmed my hope. "But I just hope that what I do in my life makes it easier for another one [woman] to come behind me and do what they want to do with their life." Sonia, voicing love for mathematics, may serve as an inspiration to females to find their mathematical passions and to persevere as mathematicians:

> I think of myself as a mathematician first because that is such a key part of who I am and I never thought of being female as being a key part of who I am. It just happens to be a biological fact. Whereas when I sat down and started doing those basic problems out of the college Algebra book, I had a really strong sense of this is who I am. As I learned more and more mathematics, I kept getting a stronger and stronger sense that this is a big piece of me,

and that I can't quit. I have to keep going as long as they will let me, as long as I can, as long as I can continue to learn, I have to keep going. I have a very strong sense of me being a mathematician. I can't stop.

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APPENDIX-INTERVIEW GUIDE

Background

1. Tell me alittle about yourself, your biographical background, where you grew up, went to college, things along this line.
2. When you were growing up, say, just moving into your teens and starting to think about the future, what did you think you'd be doing at the age you are now? What about when you were in your early twenties?
3. What stands out for you in your life over the past few years? What kinds of things have been important? What stays with you?
4. Tell me something about what your life is like right now. What do you care about, think about?
5. What do you think your parents expected you to be doing at this age?

Self-Descriptions

6. When you describe yourself, what comes first to mind?
7. How would you describe yourself to yourself?

Relationships

8. Describe outside influences and commitments in your life.
9. Describe how your professional identity influences relationships in family and community.

Professional Development and Career

10. What led you into the field of mathematics? What was the impetus for becoming a mathematician-a mathematics professor?
11. Were there any times that you thought you made the wrong choice in becoming a mathematics professor?
12. Can you discuss any issues or concerns that limit or favor you in your career?
13. What do you think will stay with you about your experiences here [in this school, in this program]? Probe for specific academic and nonacademic experiences.
14. How has being here changed the way you think about yourself or the world?
15. What has been most and least helpful to you about this place?
16. What are there things this [school, program, teaching environment] doesn't provide that are important to you?
17. What are your views of mathematicians (mathematics professors) in general? How would you describe the typical mathematician?
18. Describe how you think your colleagues see you.
19. How do you establish credibility with your male colleagues?

Learning Experience

20. Looking back over your whole life, can you tell me about a really powerful learning experience that you've had, in or out of school?

Gender

21. What does being a woman in the field of mathematics mean to you?
22. What are the differences between women and men, particularly in the field of mathematics?
23. How do you see yourself as a woman fitting into a predominantly male field?
24. How do you convey your voice as a woman in your field?
25. Can you describe a work (school) situation where you felt being a woman was an issue?
26. Do you think being a woman has helped you or hindered you in the field mathematics? If so, discuss.
27. How does your gender affect your workload?
28. As a [mathematics teacher, soon to be mathematics teacher], what steps can be taken to promote girls' to succeed in mathematics?
29. From your perspective, why aren't there more women in the field of mathematics?